(11) Japanese Patent Laid-Open No. 10-302676

(43) Laid-Open Date: November 13, 1998

(21) Application No. 9-107667

(22) Application Date: April 24, 1997

(71) Applicant: Canon Kabushiki Kaisha

(72) Inventor: Kazuya MIYAZAKI

(74) Agent: Patent Attorney, Johei YAMASHITA

(54) [Title of the Invention] IMAGE-FORMING APPARATUS

(57) [Abstract]

[Problem] It is difficult to make a satisfactory panel due to flow of resin in some cases.

[Solving Means] An image-forming apparatus comprising a first substrate 1 having a plurality of electron-emitting devices 5, a second substrate 2 having an image-forming member for forming an image by electrons emitted from the electron-emitting devices 5, and a spacer 11 provided between the substrates, wherein the spacer has a flat portion and a non-flat portion at the side face, the flat portion functioning as a bonding face between the first substrate 1 and/or the second substrate 2.

[Claims]

[Claim 1] An image-forming apparatus comprising a first

substrate having a plurality of electron-emitting devices, a second substrate having an image-forming member for forming an image by electrons emitted from the electron-emitting devices, and a spacer provided between the substrates, wherein the spacer has a flat portion and a non-flat portion at the side face, the flat portion functioning as a bonding face between the first substrate and/or the second substrate.

[Claim 2] The image-forming apparatus according to claim 1, wherein the electron-emitting devices are cold-cathode electron-emitting devices.

[Claim 3] The image-forming apparatus according to claim 2, wherein the electron-emitting devices are cold-cathode surface-conductive electron-emitting devices.

[Claim 4] The image-forming apparatus according to any one of claims 1 to 3, wherein the image-forming member comprises an anode and a fluorescent material.

[Claim 5] The image-forming apparatus according to any one of claims 1 to 4, wherein the spacer comprises a heat-resistant resin.

[Claim 6] The image-forming apparatus according to claim 1, wherein the spacer is formed by thermal compression of the heat-resistant resin.

[Claim 7] The image-forming apparatus according to claim 5, wherein the spacer is formed by injection molding of the heat-resistant resin.

[Claim 8] The image-forming apparatus according to claim 5, wherein the heat-resistant resin is a polyimide resin or a polybenzimidazole resin.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention] The present invention relates to image-forming apparatuses and particularly relates to an image-forming apparatus including electron-emitting devices.

[0002]

[Description of the Related Arts] A known image-forming apparatus including electron-emitting devices is a flat electron-beam display panel having an electron source substrate having many cold-cathode electron-emitting devices and an anode substrate having transparent electrodes and a fluorescent material and being parallel to the electron source substrate, panel being evacuated to vacuum. Among such image-forming apparatuses, a type including field-emission electron-emitting devices is disclosed by, for example, I. Brodie, "Advanced technology: flat cold-cathode CRTs", Information Display, 1/89, 17(1989). A type including surface-conductive electron-emitting devices is disclosed in, for example, United States Patent No. 5,066,883. Flat electron-beam display panels are suitable for a reduction in weight and an increase in screen size

compared with widely-used cathode-ray tube (CRT) displays, and can display images having higher brightness and higher quality compared with other types of flat display panel, such as a liquid crystal flat display panel, a plasma display, and an electroluminescent display.

[0003] Fig. 14 is an exploded isometric view illustrating an outline structure of a known electron-beam display panel, and Fig. 15 is a cross-sectional view taken along line A-A' in Fig. 14. The structure of the known electron-beam display panel shown in Figs. 14 and 15 will be described in detail. In the drawings, reference numeral 101 represents a rear plate being an electron source substrate, reference numeral 102 is a face plate being an anode substrate, and reference numeral 103 is a frame, these forming a vacuum case. Reference numeral 104 represents a glass substrate being a base of the rear plate, reference numeral 105 represents an electron-emitting device, and reference numerals 106a and 106b represent electrodes for applying a voltage to the electron-emitting devices 105. Scanning electrodes 107a and signal electrodes 107b are wiring electrodes and are connected to the electrodes 106a and 106b, respectively. Reference numeral 108 represents a glass substrate being a base of the faceplate, reference numeral 109 represents a transparent electrode, and reference numeral 110 represents a fluorescent material. Reference

numeral 111 is a spacer that supports the rear plate 101 and the faceplate 102 at a predetermined distance and functions as a supporting member against ambient pressure.

[0004] In order to form an image in this electron-beam display panel, a predetermined voltage is sequentially applied to one of the scanning electrodes 107a and one of signal electrodes 107b arranged in a matrix to selectively drive a predetermined electron-emitting device 105 lying at the intersection in the matrix, so that the fluorescent material 110 is irradiated with emitted electrons to form a bright spot at the predetermined position. In order to achieve a brighter spot by acceleration of emitted electrons, a higher voltage is applied to the transparent electrode 109 so that the transparent electrode 109 has a positive potential relative to the electron-emitting device 105. The voltage applied depends on the properties of the fluorescent material and ranges from several hundred volts to several tens of volts. Thus, the distance d between the rear plate 101 and the faceplate 102 is determined such that the voltage applied does not cause vacuum dielectric breakdown (discharge).

[0005] Requirements for materials used in the spacer 111 include (A) sufficiently high strength against ambient pressure (compression strength), (B) heat resistance durable heating in the production steps and high-vacuum forming

steps and matching of thermal expansion coefficient to the substrates and frame of the display panel, (C) high resistance (high insulation) having withstand voltage durable to the high voltage applied, (D) a small gas evolution rate to maintain high vacuum, and (E) high processability for achieving high dimensional accuracy and high productivity. In general, glass is used.

[0006] In "Advanced technology: flat cold-cathode CRTs" (Information Display, pages 17 to 19, January 1989) and United States Patent No. 5,063,327, Ivor Brodie discloses a polyimide spacer. Photosensitive polyimide is applied to a substrate by spin coating, is prebaked, is subjected to photolithography (mask exposure, development, and cleaning), and is vacuum-baked. Finally, a polyimide space with a height of 100 μm is formed on a cathode substrate. Another example of a photosensitive polyimide is disclosed in United States Patent No. 5,371,433.

[0007]

[Problems to be Solved by the Invention] Use of such spacer materials, however, caused the following problems.

[0008] General glass materials are relatively desirable in mechanical strength, thermal properties, and gas evolution properties. Furthermore, the materials have high processability and productivity and thus can be easily used as spacers. On the withstand voltage, however,

electrostatic charge at the surface (generated by secondary electron emission) readily causes surface discharge. As a result, a sufficiently high voltage cannot be applied and display with sufficient brightness is not achieved.

[0009] On the other hand, in a spacer formed with a polyimide resin by photolithography, mechanical strength is inferior to that of glass material. However, the number of spacers disposed can be easily increased, resulting in high strength against atmospheric pressure. Although heat resistance and gas evolution properties are slightly inferior to those of glass material, the polyimide can be used in a glass case without problem by adequate annealing or the like. On electrical properties, dielectric strength and surface withstand voltage are high. However, the polyamide resin has the following problems on processability.

[0010] According to the above photolithographic processing, the height of the polyimide spacer that can be formed by one step is at most several micrometers to several tens of micrometers; hence, this step must be repeated many times to form a height of several millimeters.

[0011] As described above, the spacer must have a threshold height for effective evacuation inside the display to high vacuum and for preventing electrical discharge. Thus, the repeat of the step by many times disadvantageously causes an increase in operation costs.

[0012] In this step, as the distance d increases, the spacer may fall down or break off, resulting in a decrease in yield ratio in this step.

[0013] In order to prevent such a decrease in yield ratio, the width of the spacer must be large. However, a large width of the spacer impairs fabrication of high-definition image-forming apparatuses.

[0014] Coating of polyimide on the surface of a substrate or a front glass inevitably requires a baking step; hence, the production process (order) of the substrate or the front glass is limited.

[0015] If failure occurs during making the polyimide spacer, both the polyimide spacer and the glass substrate must be discarded, resulting in an increase in expense and material loss.

[0016] Thus, the height of the spacer that can be available in practice is at most several hundred micrometers. As a result, a voltage applicable to the faceplate is limited. Thus, a high-acceleration fluorescent material having superior properties, which is used in current CRTs (acceleration voltage: several kilovolts to several tens of kilovolts), cannot be readily used, and a low-voltage fluorescent material having low brightness and low color purity must be used.

[0017] Furthermore, the step of forming the spacer is

carried out on the rear plate or the face plate, the polyimide may remain on the rear plate or the faceplate, and thus electron-emitting devices may be damaged.

[0018] Accordingly, an object of the present invention is to provide an image-forming apparatus including a spacer composed of a resin that exhibits high dielectric withstand voltage and high surface withstand voltage, that has a large height, that is suitable for mass production, and that can be produced at reduced costs compared with the above-described photolithography, although this spacer is inferior to glass material in mechanical strength. Another object is to provide an image-forming apparatus including a spacer that does not require a troublesome process used when many spacers are arranged to improve mechanical strength.

[0019]

[Solving Means] The present invention is accomplished by intensive investigation for solving the above problems and has the following constitution.

[0020] An image-forming apparatus according to the present invention includes a first substrate having a plurality of electron-emitting devices, a second substrate having an image-forming member for forming an image by electrons emitted from the electron-emitting devices, and a spacer provided between the substrates, wherein the spacer has a flat portion and a non-flat portion at the side face, the

flat portion functioning as a bonding face between the first substrate and/or the second substrate.

[0021] The present invention will now be described together the technical background of the present invention.

[0022] The inventor investigated use of a self-supported spacer formed by thermal compression of a sheet resin, as a resin spacer of an image-forming apparatus. A spacer with a large height can be produced by mass production.

[0023] However, the inventor found that the spacer formed by thermal compression of the sheet resin might have different pitches, that is, might have different side shapes caused by a difference in tension during thermal compression, depending on the shape and thickness of the spacer, as shown in Fig. 3. More specifically, large tension is applied to a short pitch portion compared to a long pitch portion. Thus, the side width of the short pitch portion is smaller than that of the long pitch portion.

[0024] The inventors made an image-forming apparatus using this spacer, and discovered that a large amount of adhesive is required and the adhesive flows into the device portion via the (relatively flat) side of the long pitch portion in some cases when the (non-flat) side of the short pitch portion is used as a bonding face, and discovered that this phenomenon precludes production of a satisfactory panel.

[0025] The present invention is achieved for solving these

problems. A spacer having flat sides and non-flat sides is formed by thermal compression of a sheet of a heat-resistant resin as described above wherein relatively large tension is applied to the non-flat sides at the short pitch portions, whereas relatively small tension is applied to the flat sides at the long pitch portions. The plat portions of the spacer are used as bonding surfaces whereas the non-flat portions of the spacer are used as non-bonding surfaces. That is, the adhesive is not applied to the non-flat portions, which generally require a large amount of adhesive, in order to prevent flow of the adhesive.

[0026] Since the non-flat portions are used as non-bonding surfaces, a gap can be provided between the faceplate (rear plate) and the spacer, improving conductance during evacuation in the image-forming apparatus and reducing the evacuation time by a getter after sealing.

[0027] The electron-emitting devices used in the present invention are preferably cold-cathode surface-conductive electron-emitting devices, and more preferably surface-conductive electron-emitting devices, although may be of a thermoelectron type. Preferably, the image-forming member includes an anode and a fluorescent material.

[0028] Preferably, the spacer is composed of a heat-resistant resin such as a polyimide resin or a polybenzimidazole resin. The adhesive for bonding the

spacer to the rear plate or the faceplate is preferably a polyimide or polybenzimidazole adhesive, which exhibits high heat resistance, a reduced amount of gas evolution, and a thermal expansion coefficient the same as that of the spacer material.

[0029] The present invention is not limited to the spacer formed by thermal compression and includes spacers formed by other production processes such as injection molding. In other words, the present invention includes all spacers having flat side portions and non-flat side portions.

[0030] According to the present invention, a flat image-forming apparatus having a large screen that can display uniform clear images can be fabricated at reduced costs with a high yield ratio.

[0031] The spacer according to the present invention is particularly suitable for image-forming apparatuses such as a display, and is also applicable to other applications as a spacer for maintaining the distance between two opposing substrates. In an image-forming apparatus including electron-emitting devices, the spacer must be durable in atmospheric pressure because the space between the substrates is maintained in vacuum. The spacer according to the present invention can also be applicable to, for example, a plasma display in which the interior is maintained at a lower pressure than the atmospheric pressure.

[0032]

[Embodiments] Preferred embodiments of the present invention will be described below.

[0033] Fig. 1 is an exploded schematic perspective view showing the construction of an image-forming apparatus according to an embodiment of the present invention, and Fig. 2 is a sectional view taken along line A-A' in Fig. 1.

[0034] In Fig. 1, reference numeral 1 denotes a rear plate serving as an electron source substrate; reference numeral 2, a faceplate serving as an anode substrate; reference numeral 3, a frame; reference numeral 4, a base substrate of the rear plate 1; and reference numeral 5, an electron-emitting device 5. Reference numerals 6a and 6b each denote an electrode for applying a voltage to the electron-emitting device 5, and reference numeral 7a (scanning electrode) and 7b (signal electrode) denote wiring electrodes connected to the electrodes 6a and 6b, respectively. Reference numeral 8 denotes a base substrate of the faceplate 2; reference numeral 9, a transparent electrode; reference numeral 10, a fluorescent material; and reference numeral 11, a spacer. Although, in this embodiment, the rear plate 1 is connected to the spacer 11, the faceplate 2 may be connected to the spacer 11 with an adhesive coated on the faceplate 2.

[0035] Of course, both the rear plate 1 and the faceplate 2 may be connected to the spacer 11.

[0036] Also, in Fig. 1, the flat side portions 11a of the spacer 11, which are used as bonding surfaces, are parallel to the Y direction. However, as shown in Fig. 13, the flat side portions 11a of the spacer 11, which are used as bonding surfaces, may be parallel to the X direction.

[0037] The rear plate 1 serves as the electron source substrate having many electron-emitting devices arranged on the substrate 4. As the substrate 4, a quartz glass substrate, a soda-lime glass substrate, a glass substrate having a reduced content of impurities such as Na, and the like, a glass substrate comprising soda-lime glass and SiO_2 laminated thereon, a ceramic substrate of alumina or the like, a Si substrate, or the like can be used. Particularly, in forming a large-screen display panel, a soda-lime glass substrate, a potassium-substituted glass substrate, a glass substrate comprising soda-lime glass and SiO_2 laminated thereon by a liquid phase growth method, a sol-gel method, or a sputtering method, or the like is preferably used because of relatively low cost.

[0038] In this embodiment, a surface conduction-type electron-emitting device is used as each of the electron-emitting devices 5. Figs. 5(a) and 5(b) are enlarged schematic views showing a surface conduction-type electron-emitting device used in the image-forming apparatus shown in Figs. 1 and 2. Fig. 5(a) is a plan view, and Fig. 5(b) is a

sectional view. In Fig. 5, the same portions as those shown in Figs. 1 and 2 are denoted by the same reference numerals as in Figs. 1 and 2.

[0039] In Figs. 5(a) and 5(b), reference numeral 31 denotes a conductive thin film, and reference numeral 32 denotes an electron-emitting section. As the conductive thin film 31, for example, a fine particle film comprising conductive fine particles and having a thickness in the range of 10 Å to 500 Å is preferably used. Any one of various conductors and semiconductors can be used as a material for forming the conductive thin film 31. Particularly, Pd, Pt, Ag, Au, PdO, or the like which is obtained by burning an organic compound containing a noble metal element such as Pd, Pt, Ag, Au, or the like is preferably used. The electron-emitting section 32 comprises a high-resistance crack formed in the conductive thin film 31. In some cases, the electron-emitting section 32 contains conductive fine particles having a particle diameter in the range of several angstroms to hundreds angstroms and containing the constituent element of the conductive thin film 31, carbon and a carbon compound.

[0040] Also, a general conductive material can be used for the electrodes 6a and 6b. For example, the material can be appropriately selected from printed conductors each composed of glass, a metal or alloy of Ni, Cr, Au, Mo, W, Pt, Ti, Al, Cu, Pd, or the like, and a metal or metal oxide such as Pd,

Ag, Au, RuO_2, Pd-Ag, or the like; transparent conductors such as In_2O_3-SnO_2 and the like; semiconductor and conductor materials such as polysilicon and the like.

[0041] As the arrangement of the electron-emitting devices 5, any of various arrangements may be used. This embodiment uses a simple matrix arrangement in which a plurality of the electron-emitting devices 5 is arranged in the X direction and Y direction to form a matrix, the electrodes 6a of a plurality of the electron-emitting devices 5 arranged in a same line are connected to the X-direction wiring electrodes 7a in common, and the other electrodes 6b of a plurality of the electron-emitting devices 5 arranged in a same column are connected to the Y-direction wiring electrodes 7b in common. The X-direction wiring electrodes 7a and the Y-direction wiring electrodes 7b can be formed by a vacuum deposition method, a printing method, a sputtering method or the like using a conductive metal. The wiring material, thickness and width are appropriately designed. Furthermore, an insulating interlayer not shown in the drawings is an insulator layer formed by a vacuum deposition method, a printing method, a sputtering method, or the like using glass, ceramic, or the like. For example, the insulating interlayer is formed in a desired shape over the entire surface of the substrate 4 or on a part of the surface of the substrate 4 on which the X-direction wiring electrodes

7a are formed. Particularly, the thickness, material and production method are appropriately set so that the insulating interlayer resists a potential difference at each intersection of the X-direction wiring electrodes 7a and the Y-direction wiring electrodes 7b. Furthermore, a scanning signal applying means (not shown) is connected to the X-direction wiring electrodes 7a, for applying a scanning signal for selecting a line of the electron-emitting devices 5 arranged in the X direction. On the other hand, a modulating signal generating means (not shown) is connected to the Y-direction wiring electrodes 7b, for modulating the electron-emitting devices 5 arranged in each column in the Y direction according to an input signal. The driving voltage applied to each electron-emitting device is supplied as a differential voltage between the scanning signal and modulating signal applied to each device.

[0042] In the above-described construction, the devices can be individually selected and independently driven by simple matrix driving.

[0043] Also, a ladder-like arrangement may be used, in which many electron-emitting devices are arranged in parallel and are connected together at both ends to form many lines of the electron-emitting devices (line direction), and the electrons emitted from the electron-emitting devices are controlled and driven by a control electrode (referred to as

a "grid") disposed above the electron-emitting devices in the direction (column direction) perpendicular to the line direction. The present invention is not limited to these arrangements.

[0044] The faceplate 2 serves as the anode substrate having the transparent electrode 9 and the fluorescent film 10 formed on the surface of the substrate 8. The substrate 8 is of course transparent, and the substrate 8 preferably has the same mechanical strength and thermal physical properties as those of the rear plate substrate 4. In forming a large-screen display panel, a soda-lime glass substrate, a potassium glass substrate, a glass substrate comprising soda-lime glass and SiO_2 laminated thereon by a liquid phase growth method, a sol-gel method, a sputtering method, or the like is preferably used. A positive high voltage Va is applied to the transparent electrode 9 from an external power supply not shown in the drawings. As a result, the electrons emitted from the electron-emitting devices 5 are attracted by the faceplate 2, and accelerated to irradiate the fluorescent film 10. If incident electrons have energy sufficient to emit light from the fluorescent film 10, a luminescent spot can be obtained in the fluorescent film 10. In a fluorescent material generally used for color TV CRT, electrons are accelerated with an acceleration voltage of several kV to several tens kV to achieve high luminance and

good coloring by irradiation. Since a CRT fluorescent material is relatively inexpensive and has high performance, the material is preferably used in the present invention. In a general technique, an aluminum thin film is formed as a metal back (not shown) on the surface of the fluorescent film 10. The purpose of the metal back is to improve luminance by mirror reflection in which the light emitted from the fluorescent material to the rear plate 1 is reflected toward the faceplate 2, and to protect the fluorescent material from damage by collision with the negative ions generated in an outer case. The metal back can also be used as en electrode for applying an electron beam accelerating voltage. In this case, the transparent electrode 9 is not necessarily provided. The present invention can be applied to any case.

[0045] The frame 3 is connected to the rear plate 1 and the faceplate 2 to form the outer case. Although the method for connecting the frame 3 to the rear plate 1 and the faceplate 2 depends upon the constituent materials of the rear plate 1, the faceplate 2, and the frame 3. However, in the use of glass, the frame 3 is connected to the rear plate 1 and the faceplate 2 by welding with glass frit.

[0046] The spacer 11 is provided for maintaining atmospheric pressure resistance and keeping the distance d between the rear plate 1 and the faceplate 2. The distance d must be a

large value sufficient to prevent the occurrence of discharge in vacuum due to the high voltage Va. On the other hand, the electrons emitted from the electron-emitting devices 5 have a finite divergent angle, and thus with an excessively large distance, adjacent pixels overlap with each other to cause color mixing or a decrease in contrast. Therefore, with the voltage Va of several kV to several tens kV, the distance d, i.e., the spacer height, is preferably set to several hundreds μm to several mm.

[0047] The spacer base material is required to have properties such as sufficient resistance to atmospheric pressure, resistance to a thermal process in air or vacuum, the same degree of thermal expansion coefficient as those of the rear plate 1, the faceplate 2 and the frame 3, excellent processability and mass production ability, etc. The atmospheric pressure resistance can be satisfied to some extent by increasing the number of the spacers 11 provided in a display panel as long as the spacer material has excellent processability and mass production ability. The thermal process in air or vacuum means, for example, a heat treatment (sealing) at about 400°C in air in the step of forming the outer case with the glass frit, or a heating step at 200°C or more in vacuum for forming a high vacuum. A material little causing thermal deformation, fusion and decomposition in this heating step is used as the spacer

material.

[0048] When a material having a thermal expansion coefficient greatly different from those of the rear plate 1, the faceplate 2, and the frame 3 is used, the entire panel is deformed or broken in the heating step in some cases. With respect to the processability and mass production ability, of course, the material is preferably inexpensive. However, in the present invention, a sheet of a heat-resistant resin such as polyimide resin, polybenzimidazole resin, or the like is preferably molded in a self-supported shape by heat pressing. The present invention is not limited to the spacer formed by heat-pressing a heat-resistant resin, and a space formed by, for example, injection molding may be used as long as the spacer has different heights in the direction of the space between the face pate and the rear plate, like the spacer formed by heat pressing does. The production method is not limited.

[0049] As the adhesive (not shown) used for connecting the spacer 11, like the spacer 11, an adhesive having the same degree of thermal expansion coefficient as those of the rear plate 1 or faceplate 2, and the frame 3 is preferably used, and an adhesive further having excellent heat resistance, atmospheric pressure resistance and property of low gas emission is more preferably used.

[0050]

[Examples] Although the present invention will be described in detail below with reference to examples, the present invention is not limited to these examples. The present invention includes replacement of each component and a design change within a scope in which the object of the invention can be achieved.

[Example 1] Fig. 4 is a schematic drawing showing the whole construction of an image-forming apparatus in which the basic construction is the same as that shown in Figs. 1 and 2. In Fig. 4, the same portions as those shown in Figs. 1 and 2 are denoted by the same reference numerals in Figs. 1 and 2. In this figure, reference numeral 41 denotes a metal back.

[0051] Figs. 6 to 12 show a method for manufacturing an image-forming apparatus according to the present invention. The basic construction of the image-forming apparatus of the present invention and the manufacturing method therefor will be described with reference to Figs. 4 and 6 to 12. Figs. 6 to 12 are enlarged views each showing a step of producing the vicinity of few electron-emitting devices for the sake of simplicity. In this example, the image-forming apparatus comprises many surface conduction-type electron-emitting devices which are arranged in a simple matrix.

(Step-a) First, as shown in Fig. 6, the device electrodes 6a and 6b are formed on a cleaned soda-lime glass

substrate by an offset printing process. In this step, MOD (Metal Organic Deposition) paste composed of Pt as a metal component is used a thick-film paste material. After printing, the device electrodes 6a and 6b are dried at 70° C for 10 minutes and then finally burned. The burning temperature is 550° C, and the peak retention time is about 8 minutes. The thickness after printing and burning is 0.3 μm or less.

(Step-b) Next, as shown in Fig. 7, the electrode wiring layers (signal side) 7a are formed by a thick-film screen printing process. In this step, Ag-containing thick-film paste NP-4035CA produced by Noritake Company is used as a paste material. The burning temperature is 400° C, and the peak retention time is about 13 minutes. The thickness after printing and burning is 7 μm or less.

(Step-c) Next, as shown in Fig. 8, an insulating interlayer 12a is formed by a thick-film screen printing process. In this step, a mixture of PbO as a main component and a glass binder is used as a paste material. The burning temperature is 480° C, and the peak retention time is about 13 minutes. The thickness after printing and burning is 36 μm or less. In order to secure insulation between upper and lower layers, the insulating interlayer is usually formed by three times each of printing and burning. In some cases, a film formed with thick-film paste is a porous film, and thus

the pores of the film are filled with paste by repeating printing and burning several times to secure insulation.

(Step-d) Next, as shown in Fig. 9, the electrode wiring layers (scanning side) 7b functioning as scanning-side wiring layers are formed by a thick-film screen printing process. In this step, Ag-containing thick-film paste NP-4035CA produced by Noritake Company is used as a paste material. The burning temperature is 400° C, and the peak retention time is about 13 minutes. The thickness after printing and burning is 11 μm or less.

[0052] A wiring matrix is completed through the above-described steps.

(Step-e) A mask used for forming the conductive thin films 31 of the electron-emitting devices in this step has openings each formed over the electrode layers 6a and 6b. A Cr film of 100 nm in thickness is deposited and patterned by vacuum deposition through the mask, and then organic Pd (ccp4230 produced by Okuno Chemical Industries Co., Ltd.) is coated on the Cr film by spin coating using a spinner, and burned by heating at 300° C for 10 minutes. The thus-formed conductive thin films 31 comprising fine particles composed of Pd as a main element have a thickness of 10 nm, and a sheet resistance of 5×10^4 Ω/□.

[0053] The Cr film and the conductive thin films 31 are etched with an acid etchant to form a desired pattern (Fig.

10).

(Step-f) Next, as shown in Fig. 11, an adhesive 13 is coated on the electrode wiring layers 7b. As the adhesive, a polyimide adhesive HT-300V produced by Konishi Co. Ltd. is used, and coated by a dispenser. Although the dispenser coating conditions depend upon the solute concentration of the adhesive, the adhesive having a solute concentration of 15% is coated with a nozzle size of 175 μm under the conditions including a discharge pressure of 2.0 kgf/cm^2, a nozzle-wiring gap of 150 μm, and a nozzle feed rate of 7.5 mm/sec. The width of the adhesive is 150 μm or less.

(Step-g) Next, a spacer and a rear plate are connected together by using an alignment jig (not shown). The spacer is formed in a stepped shape by heat-pressing a Kapton sheet (a super heat-resistant and super cold-resistant polyimide film produced by Toray Dupont Co., Ltd.) having a section of 100 mm x 120 μm at 420°C. In the thus-formed stepped self-supported spacer, the long pitch portions are used as bonding surfaces, and the short pitch portions are used as non-bonding surfaces (Fig. 12).

[0054] After alignment at room temperature, the spacer and the rear plate are preliminarily bonded together on the alignment jig at 70°C for 1 hour. Then, the rear plate preliminarily bonded to the spacer is removed from the alignment jig, and then cured at 250°C for 2 hours in a

clean oven to completely bond the rear plate and the spacer together.

(Step-h) Next, as shown in Fig. 4, the frame 3 is mounted on the rear plate 1 formed as described above. In this step, frit glass is previously coated on the bonding surfaces between the rear plate 1 and the frame 3. The faceplate 2 (comprising the fluorescent film 10 and the metal back 41 formed on the inner surface of the glass substrate 8) is disposed on the rear plate 1 with the frame 3 provided therebetween. However, frit glass is previously coated on the bonding surfaces between the faceplate 2 and the frame 3. The combination of the rear plate 1, the support frame 3 and the faceplate 2 is first maintained in air at 100°C for 10 minutes, heated to 300°C, maintained at 300°C for 1 hour, further heated to 400°C and then burned for 10 minutes to seal the combination.

[0055] In a monochrome display, the fluorescent film 10 comprises only a fluorescent material. However, in this example, the fluorescent material is formed in stripes. Namely, black stripes are first formed, and then each fluorescent material is coated in the spaces between the black stripes. As the material for the black stripes, a general material composed of graphite as a main component is used. The fluorescent material is coated on the glass substrate 8 by a slurry process.

[0056] The metal back 41 formed on the inner surface of the fluorescent film 10 is formed by planarizing (generally referred to as "filming") the inner surface of the fluorescent film 10 after the formation of the fluorescent film 10, and then depositing Al under vacuum.

[0057] In some cases, a transparent electrode is provided on the outer surface of the fluorescent film 10 formed the faceplate 2, for improving the conductivity of the fluorescent film 10. However, in this example, the transparent electrode is not provided because sufficient conductivity can be obtained only by the metal back.

[0058] In a color display, each fluorescent material must be aligned with the electron-emitting devices during the above-described sealing, and thus alignment is sufficiently performed.

[0059] Then, the air in the glass vessel completed as described above is exhausted by a vacuum pump through an exhaust tube (not shown) to attain a sufficiently low pressure. Then, a voltage is applied between the electrodes 6a and 6b of the electron-emitting devices 5 through vessel external terminals Dxo1 to Doxm and Doy1 to Doyn to perform a forming treatment of the conductive thin films 31, forming the electron-emitting sections 32. Furthermore, toluene is introduced into the panel from the exhaust tube of the panel through a slow leak valve, and all the electron-emitting

devices are driven in an atmosphere of 1.0×10^{-3} Pa to perform activation.

[0060] Next, the pressure is decreased to about 10^{-4} Pa, and then the exhaust tube (not shown) is heated by a gas burner to seal the outer case.

[0061] Finally, in order to maintain the pressure after sealing, gettering is performed by a high-frequency heating process.

[0062] In the image display device completed as described above in this example, a scanning signal and modulating signal are applied to each of the electron-emitting devices through the container external terminals Dox1 to Doxm and Doy1 to Doyn, respectively, from signal generating means (not shown) to emit electrons from the devices, and the high voltage Va is applied to the metal back 41 through a high-pressure terminal Hv to accelerate an electron beam. The electron beam is caused to collide with the fluorescent film 10 to excite the film and emit light, thereby displaying an image.

[0063] The image-forming apparatus of this example has no device defect due to dropping of the adhesive, and can display a uniform sharp image. Thus, a large-flat-screen image-forming apparatus can be manufactured at low cost in high yield.

[Example 2] In this example, the same steps as those in

Example 1 are performed except that Step-f and Step-g are changed to Step-f' and Step-g', respectively.

(Step-f') The adhesive 13 is coated on the electrode wiring layers 7b. A polyimide adhesive LARK-TPI produced by Mitsui Toatsu Co., Ltd. is used as the adhesive, and coated by a dispenser. Although the dispenser coating conditions depend upon the solute concentration of the adhesive, the adhesive having a solute concentration of 15% is coated with a nozzle size of 175 μm under the conditions including a discharge pressure of 2.0 kgf/cm^2, a nozzle-wiring gap of 150 μm, and a nozzle feed rate of 7.5 mm/sec. The width of the adhesive is 180 μm or less.

(Step-g') Next, a spacer and a rear plate are connected together by using an alignment jig (not shown). The spacer is formed in a stepped self-supported spacer by heat-pressing a polyimide resin sheet so that a bonding surface is 100 mm x 110 μm, and a non-bonding surface is 50 mm x 110 μm.

[0064] After alignment at room temperature, the spacer and the rear plate are preliminarily bonded together on the alignment jig at 100°C for 1 hour. Then, the rear plate preliminarily bonded to the spacer is removed from the alignment jig, and then cured at 300°C for 2 hours in a clean oven to completely bond the rear plate and the spacer together.

[0065] Then, the air in the glass vessel completed as described above is exhausted by a vacuum pump through an exhaust tube to attain a sufficiently low pressure. Then, a forming treatment and activation are performed according to the same procedures as in Example 1.

[0066] After evacuation and sealing, gettering is performed by a high-frequency heating process.

[0067] In the image display device of the present invention completed as described above, an electron beam is caused to collide with the fluorescent film in the same manner as in Example 1 to excite the film and emit light, thereby displaying an image.

[0068] The image-forming apparatus of this example has no device defect due to dropping of the adhesive, and can display a uniform sharp image. Thus, a large-flat-screen image-forming apparatus can be manufactured at low cost in high yield.

[Comparative Example] In the comparative example, the same steps as those in Example 1 are performed except that Step-f and Step-g are changed to Step-f" and Step-g", respectively.

(Step-f") The adhesive 13 is coated on the electrode wiring layers 7b. A polyimide adhesive HT-300V produced by Konishi Co., Ltd. is used as the adhesive, and coated by a dispenser. In this step, a relatively large amount of the adhesive is required because bonding surfaces are formed on

the short pitch portions where the side shape is narrowed, as described in the next step below. Although the dispenser coating conditions depend upon the solute concentration of the adhesive, the adhesive having a solute concentration of 15% is coated with a nozzle size of 175 μm under the conditions including a discharge pressure of 4.0 kgf/cm^2, and a nozzle-wiring gap of 150 μm. The width of the adhesive is 250 μm or less. In the comparative example, bonding surfaces are formed on the short pitch portions where the side shape is narrowed, and thus a large amount of the adhesive is required. Therefore, the discharge pressure is controlled to 4.0 kgf/cm^2 to increase the amount of the adhesive coated.

(Step-g") Next, a spacer and a rear plate are connected together by using an alignment jig (not shown). The spacer is formed in a stepped shape by heat-pressing a Kapton sheet having a section of 100 mm x 120 μm at 420° C. In the thus-formed stepped self-supported spacer, bonding surfaces are formed on the short pitch portions, and non-bonding surfaces are formed on the long pitch portions.

[0069] After alignment at room temperature, the spacer and the rear plate are preliminarily bonded together on the alignment jig at 70° C for 1 hour. Then, the rear plate preliminarily bonded to the spacer is removed from the alignment jig, and then cured at 250° C for 2 hours in a

clean oven to completely bond the rear plate and the spacer together.

[0070] Then, the air in the glass vessel completed as described above is exhausted by a vacuum pump through an exhaust tube to attain a sufficiently low pressure. Then, a forming treatment and activation are performed according to the same procedures as in Example 1.

[0071] After evacuation and sealing, gettering is performed by a high-frequency heating process.

[0072] In the image display device of the present invention completed as described above, an electron beam is caused to collide with the fluorescent film in the same manner as in Example 1 to excite the film and emit light, thereby displaying an image.

[0073] In the image-forming apparatus of the comparative example, when the high voltage Va was increased to 5.2 kV, deterioration was observed due to discharge in the devices. Therefore, a display image was evaluated with a Va decreased to 4.0 kV. As a result, the image exhibited low luminance and insufficient color expression, and the image was also disturbed within several minutes to fail to perform a stable display.

[0074] In the image-forming apparatus of the comparative example, the amount of the electrons emitted from the devices near the adhesive was relatively low due to dropping

of the adhesive, and a device not emitting electrons was observed. Therefore, it was difficult to display a uniform and sharp image.

[0075]

[Advantages] Ad described above, according to the present invention, an image-forming apparatus that can display satisfactory images for a long time and suitable for a high-definition image-forming apparatus such as a flat color television set.

[Brief Description of the Drawings]

[Fig. 1] is a schematic exploded isometric view illustrating an embodiment of an image-forming apparatus according to the present invention.

[Fig. 2] is a cross-sectional view illustrating an embodiment of an image-forming apparatus according to the present invention.

[Fig. 3] includes an overhead view and a side view of a spacer included in an image-forming apparatus according to the present invention.

[Fig. 4] is an entire isometric view of an embodiment of an image-forming apparatus according to the present invention.

[Fig. 5] is an enlarged outline view of a surface-conductive electron-emitting device included in an image-forming apparatus according to the present invention.

[Fig. 6] is a plan view illustrating a basic structure of an

image-forming apparatus and a method for making the apparatus according to the present invention.

[Fig. 7] is a plan view illustrating a basic structure of an image-forming apparatus and a method for making the apparatus according to the present invention.

[Fig. 8] is a plan view illustrating a basic structure of an image-forming apparatus and a method for making the apparatus according to the present invention.

[Fig. 9] is a plan view illustrating a basic structure of an image-forming apparatus and a method for making the apparatus according to the present invention.

[Fig. 10] is a plan view illustrating a basic structure of an image-forming apparatus and a method for making the apparatus according to the present invention.

[Fig. 11] is a plan view illustrating a basic structure of an image-forming apparatus and a method for making the apparatus according to the present invention.

[Fig. 12] is a plan view illustrating a basic structure of an image-forming apparatus and a method for making the apparatus according to the present invention.

[Fig. 13] is an exploded isometric view illustrating another embodiment of an image-forming apparatus according to the present invention.

[Fig. 14] is an outline view illustrating a conventional flat electron-beam display panel.

[Fig. 15] is a cross-sectional view of a conventional flat electron-beam display panel.

[Reference Numerals]

1: rear plate

2: faceplate

3: frame

4: rear plate substrate

5: electron-emitting device

6a, 6b: electrodes

7a, 7b: electrode wirings

8: faceplate substrate

9: transparent electrode

10: fluorescent film

11: spacer

12: insulating interlayer

13: adhesive

31: conductive thin film

32: electron-emitting section

41: metal back

Fig. 3

OVERHEAD VIEW

LONG PITCH PORTION

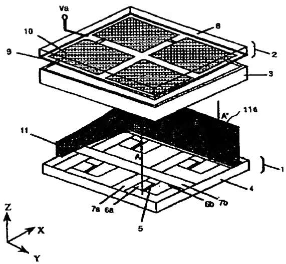
SHORT PITCH PORTION

SIDE VIEW

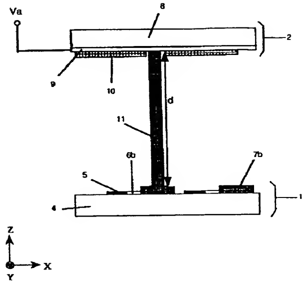
Fig. 4

HIGH-VOLTAGE TERMINAL

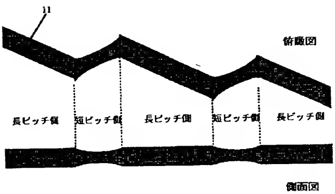
【図1】 FIG.1



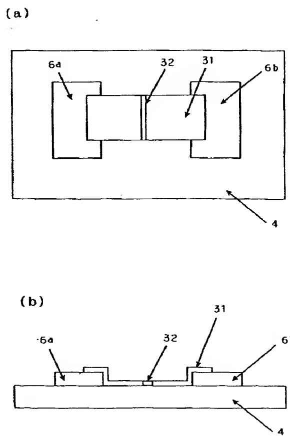
【図2】 FIG.2



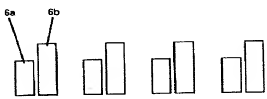
【図3】 FIG.3



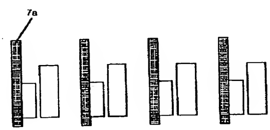
【図5】 FIG.5



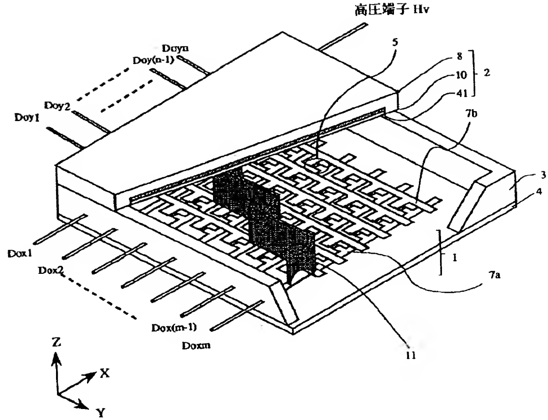
【図6】 FIG.6



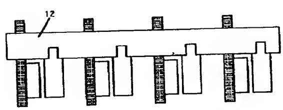
【図7】 FIG.7



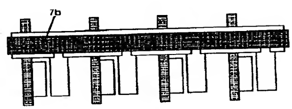
【図4】 FIG.4



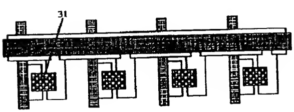
【図8】 FIG.8



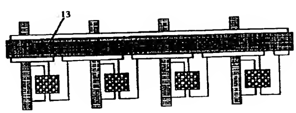
【図9】 FIG.9



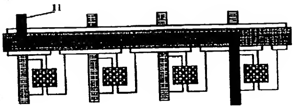
【図10】 FIG.10



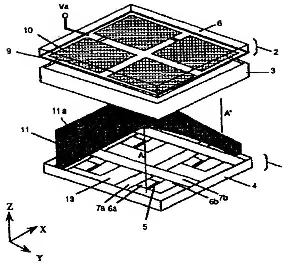
【図11】 FIG.11



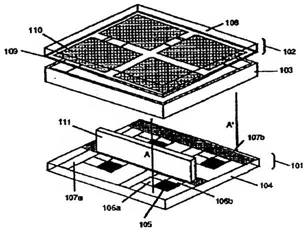
【図12】 FIG.12



【図13】 FIG.13



【図14】 FIG.14



【図15】 FIG.15